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EFFECTS OF REMEDIAL FEEDBACK IN A TECHNICAL TRAINING
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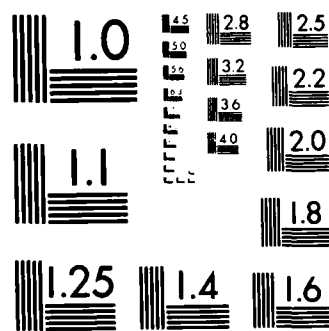
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NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN DIEGO CALIFORNIA 92152

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**EFFECTS OF REMEDIAL FEEDBACK IN A TECHNICAL
TRAINING MANAGEMENT SYSTEM: A PILOT STUDY**

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EFFECTS OF REMEDIAL FEEDBACK IN A TECHNICAL
TRAINING STUDY MANAGEMENT SYSTEM: A PILOT STUDY

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FOREWORD

This research and development was performed in support of Navy Decision Coordinating Paper, Education and Training Development (NDCP-Z0108-PN), under subproject P30.A, Adaptive Experimental Approach to Instructional Design, and under the sponsorship of the Chief of Naval Operations (OP-99). The overall objective of the subproject is to develop an empirically based instructional design support system to aid developers in deciding on instructional alternatives based on costs/benefits and specific resource limitations. The purpose of the present effort is to investigate various instructional remedial methods to determine their effects on student learning. It was approved as part of test bed research by the Experimental Training Programs Policy Board established by a Memorandum of Understanding between the Chief of Naval Education and Training and this Center.

Appreciation is expressed to the staff of the Interior Communications School, Service School Command, Naval Training Center, San Diego, California. Without their assistance and cooperation, this study could not have been performed. Mr. Anthony Sassano assisted in data collection and in computer programming. Test item development and analysis of subject matter were conducted under contract N00123-76-C-2045 to Courseware, Inc.

Results of this research and development are intended for use by the Chief of Naval Education and Training Support, specifically the Instructional Program Development Centers, the Chief of Naval Technical Training, and the Chief of Naval Education and Training.

DONALD F. PARKER
Commanding Officer

Letter on file

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SUMMARY

Problem

Under computer-managed study management systems, which are used in some Navy training courses, students are assigned material to study and then quiz-ized via computer to determine how much they have learned. Depending upon their quiz performance, students are either given a new assignment or told to review the material covered by the quiz. In the latter case, they are usually provided remedial information or feedback prior to retesting. Since procedures for providing this remedial information vary, a need exists to determine those that are most effective and efficient.

Objective

7 The purpose of this study was to determine whether elective remediation procedures (i.e., those that allow students the option of reviewing the material) are as efficient and effective as those that provide required or no remediation.

Method

Q To test the hypothesis that allowing student control over remediation will make learning more efficient without sacrificing effectiveness, 92 Interior Communications "A" School students were assigned to three remedial feedback conditions: (1) Required remediation (R), which required subjects to receive remediation for missed test items, (2) elective remediation (E), which allowed students to elect whether or not to receive remediation, and (3) no remediation (N). Test performance, study time required between tests, and procedure effectiveness were compared for the three conditions.

Results

5 The performance of subjects assigned to the E condition was significantly better than that of those assigned to either the R or N conditions. However, they required somewhat more time than those in the N condition.

Conclusions

Although the use of student-controlled remediation in Navy training clearly has potential for enhancing student performance and increasing training effectiveness, the problem's complexity and the results of other research necessitate further validation of such remediation in Navy training courses. Elective remediation may not always be superior, and there apparently are limits as to how much and what type of remediation should be under a particular student's control.

Recommendations

1. The present study should be replicated to ascertain the generality of elective remediation in Navy training.

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INTRODUCTION

Problem

Under the Interservices Procedures for Instructional Systems Development (NAVEDTRA 106A), the Navy has options for using study management systems in some training courses. In some schools (e.g., Boiler Technician's/Machinist's Mate School, Great Lakes), computer-managed instruction (CMI) is included as part of a study management system. The usual procedure is that students are assigned some material to study, and then are given a quiz via the computer. Depending upon their quiz performance, students are assigned new material or told to review materials relevant to errors made on the quiz. In the latter case, they are usually provided with remedial feedback prior to retesting to facilitate their learning processes. Procedures for providing such remedial feedback vary and it is not clear which are most effective and efficient. Since students are sometimes aware of reasons for their incorrect responses, they may not need to review the material. Allowing them this option may produce gains in training efficiency.

Purpose

The purpose of this study was to determine whether elective remediation, which allows students the option of reviewing the material, is as efficient and effective as required or no remediation.

Background

The term "feedback" can describe any of a number of procedures used to tell a student whether or not a response to a question was correct. It can range from simple indications of "right" or "wrong," through restatements of correct answers, to elaborate explanations or reinstruction. Feedback has long been acknowledged as necessary for learning (e.g., Judd, 1970; Thorndike, 1931; Ammons, 1956), but, the mechanisms responsible for this facilitation are frequently misunderstood. As a result, in both research and instruction, feedback is often used inappropriately, thus generating confusing or contradictory experimental results and inefficient, ineffective instruction.

Common sense leads one to expect that, the more elaborate the feedback, the better the performance, since providing more information promotes better understanding. However, the expectation is not decisively supported in the research literature (Kulhavy, 1976). Similarly, although providing immediate feedback would be expected to provide maximum learning, substantial evidence exists that delaying corrective feedback results in superior retention (Sturges, 1978). Therefore, since these common sense ideas are at best incomplete, it is unfortunate that so much instructional practice is based on them.

Comprehensive reviews of the results of the numerous studies on feedback and remediation have been provided in recent papers by Kulhavy (1976) and Sturges (1978). Thus, this section includes reviews of selected studies that (1) indicate that students' reaction to feedback conditions is of primary importance in determining later performance, and (2) suggest that students can make accurate judgments about what they have learned.

It has been suggested that the students' reaction to feedback determines its effectiveness. For example, Sturges (1972) found that, if feedback requires students to read through the alternatives for a multiple-choice item to find the correct one, their later test performance will be enhanced. Surber and Anderson (1975) stated that the effect of feedback on retention depends upon the correctness of the initial answer, with more effect on incorrect answers, apparently because students attend more to the feedback in searching for corrective information.

More direct evidence comes from studies that ascertain students' confidence in their responses and then evaluate the effect of feedback. Kulhavy (1976) reported that, in answering multiple-choice questions, students look at the alternatives, eliminate the ones that are obviously wrong, and then select the most likely answer from those remaining. He suggested that students' use of feedback depends largely on the confidence they have in their initial response and on whether or not their answer was correct; that is, when confidence is high and initial answers are correct, students usually give only cursory attention to feedback. Melching (1966) found that, when he gave them the option, subjects requested little feedback for answers in which they were confident. On the other hand, when their confidence was high but the answer was wrong, students expended substantial effort in finding the source of their error. Since low confidence indicates low comprehension of either material or questions (or both), feedback will probably have minimal effects unless accompanied by elaborate remediation or reinstruction. Kulhavy's (1976) findings support this analysis and emphasize the students role in determining feedback's effects on retention. To be more effective, methods of presenting feedback must be developed that take learner knowledge and confidence into account.

Work on learner control also suggests that the learner's role is an important determiner of what and how well materials are learned. Mager and McCann (1961) and Mager and Clark (1963) found that learner control of the sequence of materials produced more effective learning than preorganized sequences. Merrill (1973) suggested that students learn how to learn when given opportunities to structure the sequence of materials. Although such "learner control" may not be useful for all learning tasks (Judd, O'Neil, & Spelt, 1974; Steinberg, 1977), the importance of the learner's perceptions and understanding is apparent.

METHOD

Research Hypothesis

The present study is a further test of Kulhavy's (1976) conclusion that students' use of test performance feedback depends upon their confidence in their initial answers and on whether or not their answers were correct, and Merrill's (1973) conclusion that students learn how to learn when given opportunities to control the learning process. If Kulhavy was correct, then students should be aware of their level of knowledge and should be able to select remedial sequences when needed. It then follows that giving the student control over the remediation process should make learning more efficient without sacrificing effectiveness. This hypothesis is examined in the present study by providing three conditions of remedial feedback: (1) required remediation (R) for missed items; that is, subjects were required to receive remediation, (2) elective remediation (E), in which students could decide whether or not to receive remediation, and (3) no remediation (N). Assuming that some answers can be quickly corrected or understood by students without remedial feedback, it is expected that (1) the E condition should provide the most efficient approach, (2) the R condition should be less efficient because of the time required to go through the material to reprocess all errors, and (3) the N condition should produce poorer performance but take less time.

Circuits II is a 1-week, self-study unit comprised of seven lessons, including one of the Ship's Telephone System and one on the Dummy Log. Before students begin the lessons, they are required to take a pretest, consisting of 50 multiple-choice (four alternatives) questions. If they score 90 percent or more on this test, they are not required to take the unit. If they do not, they study the seven lessons and take the lesson tests, which are administered by the SMS and which consist of both multiple-choice and matching items. The criterion level for the lesson tests is 70 percent, except for the Ship's Telephone System test, which is 80 percent. If students score below the lesson test criterion, they must retake the test on the SMS. If they fail to reach the criterion after three tries, they must take a written test given by the instructor. Test items are not changed for retakes. When students have successfully completed all seven lessons, they are required to take a 50 item posttest. A score of 64 percent on this test is required for course completion.

Sample

Subjects included 92 IC "A" School students enrolled in the Circuits II unit who failed the first lesson tests on the Ship's Telephone System and the Dummy Log lessons. Of these, 31 were assigned to the N condition; 32, the E condition; and 29, the R condition. The Ship's Telephone System and Dummy Log lessons were selected for this study because they were considered the most difficult.

Procedure

The study was planned to be conducted over a 9-week period, with 3 weeks being randomly assigned for testing subjects in each of the three remedial

conditions. However, the R was run for a fourth week because so few students failed the Ship's Telephone and Dummy Log lessons during the third week assigned to the condition.

Students took the pretest on the Friday before they were scheduled to begin the Circuit II unit. In completing this unit, all students took the Ship's Telephone System lesson first and were then free to proceed through the rest of the lessons at their own pace. All students completed the course by the fourth class day.

The instructions (i.e., remedial feedback) given to students upon failing a test were manipulated, depending on the remedial condition to which they were assigned. The instructions provided for subjects assigned to the N condition consisted of the following message:

You have failed this test because you scored below 70 (80) percent. You will now see the items you answered incorrectly without the answers.

The instructions provided for subjects in the R condition included the same message as above, as well as the following directions:

To study the material which gave you difficulty, write down the references that will be displayed at the top (of the page) for each item answered incorrectly.

Finally, the instructions provided for subjects in the E condition included the message for the N condition, as well as the following:

If you wish to study material for the missed item, press the HELP key and write down the references displayed for that item.

After receiving instructions, subjects could either retake the test immediately or request assignment to a study carrel. If they failed a second time, they had the same option.

Dependent Variables

The dependent variables included the (1) percent correct of the questions relevant to the Ship's Telephone System and Dummy Log lessons in the pre- and posttests, (2) scores for all trials of lesson tests for the Ship's Telephone System and Dummy Log lessons, (3) the time required between Tests 1 and 2 and between Test 1 and Posttest for these two lessons, and (4) indices measuring effectiveness of time required for remediation.

RESULTS

Performance

Table 1 provides mean test results for the subjects assigned to the three feedback conditions. There were no significant differences between subjects assigned to the three conditions on the pretest or on the first and second tests for both lessons. However, on the posttest, subjects assigned to the elective remediation (E) condition scored substantially higher on items relevant to both lessons. An analysis of covariance, in which pretest scores were used as the covariate, found significant differences among conditions for the Ship's Telephone System lesson, $F(2,88) = 3.65$, $p < .05$. Although subjects assigned to the E condition also performed better on the Dummy Log items, the difference was not significant. The lack of a reliable difference here may be attributed to the small number of Dummy Log items.

Study Time

Table 2 provides study times (minutes) required between tests. Subjects assigned to the required remediation (R) condition consistently required more study time than those assigned to the other conditions. They took significantly longer than the other subjects between the Ship's Telephone System lesson tests, and between the Dummy Log Test 1 and posttest. Thus, study time appears to be a direct function of the amount of remediation.

Effectiveness

Effectiveness is a function of how much improvement results from the time devoted to the task. For the present effort, an index of effectiveness was defined as the ratio of the normalized difference in gain scores ($\text{norm } \Delta g$) to the normalized accumulated difference in time between the ending and beginning of the remediation sessions ($\text{norm } \Delta t$) (i.e., $\text{norm } \Delta g / \text{norm } \Delta t$). In this manner, the ratio of normalized mean gain to normalized mean time would be $1 = \Delta g / \Delta t$. (T scores with a mean of 50 and a standard deviation of 10 were the normalized scores used.) A ratio of 1 for an individual indicates that the gain score he obtained, for the amount of time spent, is the same as the norm of the group; a ratio greater than 1, that his gain score is above the norm; and a ratio of less than 1, that his gain score is less than the norm.

Two effectiveness indices were computed for each subject—one for the study time required between Tests 1 and 2 on each lesson; and the other, for the total time required between the first lesson test and the posttest. As shown in Table 2, the effectiveness index for the total time required between the Ship's Telephone System lesson Test 1 and Posttest was significantly higher for subjects in the N and E conditions than for those in the R conditions ($F(2,88) = 4.33$, $p < .05$). There were comparable but nonsignificant differences for the Dummy Log lesson. These results supported the prediction that elective remediation would be more efficient than required remediation. Although subjects in the N and E conditions did not differ in effectiveness, the provision of active remedial information did improve performance (see Table 1).

Table 1

Test Results for Ship's Telephone System
and Dummy Log Lessons

Feedback Condition	N	Pretest		1st Lesson Test		2nd Lesson Test		Posttest	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Ship's Telephone System Lesson									
Remediation (R)	29	37.31	(14.30)	70.66	(6.92)	80.79	(8.32)	86.76	(8.89)
No Remediation (N)	31	34.19	(10.64)	72.00	(6.18)	83.74	(6.51)	88.10	(9.64)
Elective (E)	32	33.75	(14.38)	70.47	(7.09)	81.66	(6.51)	92.44*	(7.94)
Dummy Log Lesson									
Remediation (R)	29	32.56	(25.41)	57.59	(14.29)	77.78	(17.2)	76.85	(19.52)
No Remediation (N)	31	38.18	(22.18)	54.64	(14.06)	81.77	(14.35)	77.27	(24.29)
Elective (E)	32	32.26	(20.95)	53.81	(12.97)	81.68	(17.88)	83.06	(14.96)

*p < .05

Table 2

Study Time (in Minutes) Required and Effectiveness Indices
for Ship's Telephone System and Dummy Log Lessons

Feedback Condition	N	Study Time Between				Effectiveness Index for Remediation Between			
		Tests 1 & 2		Test 1 & Posttest		Tests 1 & 2		Test 1 & Posttest	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Ship's Telephone System Lesson									
Remediation (R)	29	51.54*	(42.36)	74.72*	(71.77)	.94	(.29)	.92	(.34)
No Remediation (N)	31	27.52	(15.73)	33.58	(23.45)	1.10	(.21)	1.12*	(.21)
Elective (E)	32	42.25	(35.69)	53.18	(43.65)	1.01	(.29)	1.11*	(.31)
Dummy Log Lesson									
Remediation (R)	29	13.67	(13.69)	23.41*	(27.83)	.97	(.26)	.97	(.25)
No Remediation (N)	31	13.41	(13.5)	17.41	(14.60)	1.03	(.25)	.98	(.29)
Elective (E)	32	10.06	(10.14)	12.68	(11.37)	1.04	(.25)	1.09	(.19)

*p < .05

DISCUSSION

The finding that the elective remediation (E) condition was more efficient than the other conditions supports Kulhavy's (1976) conclusion that the use a student makes of feedback depends largely on the confidence he has in his initial response and on whether or not the answer chosen was correct, and Merrill's (1973) hypothesis that students learn how to learn when given opportunities to control the learning process. More potentially important, however, was the superior performance found for students assigned to this condition. Although the authors are unaware of previous study results that demonstrate superiority, some suggestive evidence exists. For example, Lahey, Hurlock, and McCann (1973), using remediation provided by a computer-based instructional system, found similar but nonsignificant results. Students who were allowed to control their remediation obtained somewhat higher scores on a final test than those given either programmed or no remediation. Although their data indicated that subjects in the E condition performed more efficiently than those in both of the other conditions, the present data indicate that they require somewhat more time than those assigned to the no remediation (N) condition.

It is apparent that corrective remediation/feedback effects are complicated; and that the effectiveness of feedback depends on how students react to the demands placed on them by the remedial information provided, aspects of their motivation to perform, their uncertainties about the information, and so on. Such an interpretation is supported by other research. For example, Sullivan, Baker, and Schutz (1967) found that a feedback group took less time to complete the lessons than did a no-feedback group. They observed that no-feedback students spent more time trying to learn the prose material they were expected to learn, probably because of their uncertainty about task requirements. The students receiving feedback neglected some aspects of the material, apparently because the questions and feedback guided their studying selectively. Therefore, it can be hypothesized that the students receiving no feedback studied longer because of implicit or explicit demands imposed on them by task conditions. In the present experiment, presumably different task demands allowed students assigned to the N condition to ignore their errors and make less attempts at self-remediation. What needs to be understood is how to arrange the task conditions/requirements so that students progress through the material while (1) maximizing the productivity of their studying or restudying and (2) minimizing the total time spent in learning.

The effectiveness data in the present study also agree with a "law of least effort" proposed by Anderson, Kulhavy, and Andre (1971). Subjects in the E condition were able to use the remedial information and study time quite effectively. On the average, they elected to study only 35 and 44 percent of the items they missed on the first lesson test of the Ship's Telephone System lesson and the Dummy Log lesson respectively. It is interesting to note that only 7 of the 32 students in the E condition chose to receive remedial information for more than 10 items on the Ship's Telephone lesson test (more than 10 items had to be missed to fail the test). Of these students, five failed the second test. On the other hand, only 6 out of the 25 remaining students failed the second test. (A post hoc analysis

using the Fisher exact probability test revealed a significant difference between these two groups of subjects: $p = .208$.) Apparently, the students who elected to receive more remediation had inefficient and ineffective study strategies. Simple prescriptions for providing remediation are further complicated by such individual differences. More research is needed regarding these problems.

CONCLUSIONS

Although the use of student-controlled remediation in Navy training clearly has potential for enhancing student performance and increasing training effectiveness, the problem's complexity and the results of other research (e.g., Sullivan et al., 1971; Anderson et al., 1971) necessitate further validation of such remediation in Navy training courses. Elective remediation may not always be superior, and there apparently are limits to how much and what type of remediation should be under a particular student's control. Some students (perhaps bright ones) may perform well under elective remediation conditions while others do not. Lahey (Note 1) and Wulfeck (1976) observed that Navy students generally lack the ability to structure learning materials. These observations raise questions about the usefulness of elective remediation in Navy training. Clearly, more study is warranted, particularly that involving direct observation of the activities engaged in by students given optional or required feedback. Such observation should allow the development of feedback procedures that will optimize student progress in individualized and computer-managed instructional environments.

RECOMMENDATIONS

1. The present study should be replicated to ascertain the generality of elective remediation in Navy training.
2. The learning conditions in which student control of remediation is most effective should be determined, particularly with regard to Navy students.
3. The efficiency of elective remediation, along with performance levels as a function of student abilities or other characteristics, should be studied.

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